Optimization of Granite Powder used as Partial Replacement to Cement in the Design of Ready Mix Concrete of M20 Grade using IS10262:2009

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***Abstract* - The Optimization of Granite Powder and its effect on fresh and hardened properties of Ready Mix Concrete with partial replacement to Cement were investigated. Mix design of M20 Grade was done according to Indian Standard Code IS 10262:2009 using Granite Powder and Manufactured Sand. Specimens were tested for evaluation of optimum percentage of Granite Powder in Ready Mix Concrete for Compressive Strength. Workability was measured in terms of Slump and Compacting factor. The Ready Mix Concrete exhibits excellent strength with 20 percent replacement of Cement by Granite Powder along with Manufactured Sand. Granite Powder and Manufactured Sand can be used in concrete as viable alternative materials in making the Concrete. This paper proposes the Applications of Granite Powder and Manufactured Sand as an attempt towards sustainable development in India. This paper describes the feasibility of using Granite powder in Ready Mix Concrete production as partial replacement to cement. Further, this paper encourages the Engineers, Contractors and Government to accept the alternative materials for the better future.**

***Key Words* - *Ready Mix Concrete (RMC), Granite Powder, Manufactured Sand (M. Sand), Superplasticizer, Compressive Strength, Optimization*.**

INTRODUCTION

Indian Granite Stone Industry currently produces around 17.8 million tonnes of solid granite waste and out of which 12.2 million tonnes will be the rejects at the industrial sites, 5.2 million tonnes in the form of cuttings or trimmings and 0.4 million tonnes granite slurry at processing and polishing units.

Leaving the waste materials to the environment directly can cause environmental problem. Hence the reuse of waste material has been emphasized. Waste can be used to produce new products or can be used as admixtures so that natural resources are used more efficiently and the environment is protected from waste deposits. Marble stone industry generates both solid waste and stone slurry. Solid waste results from the rejects at the mine sites or at the processing units. Stone slurry is a semi-liquid substance consisting of particles originating from the sawing and the polishing processes and water used to cool and lubricate the sawing as well as polishing [6].

The scientific and industrial community must commit towards more sustainable practices. There are several reuse and recycling solutions for this industrial by-product, both at an experimental phase and in practical applications. These industrial wastes are dumped in the nearby land and the natural fertility of the soil is spoiled [9]

The reduction in waste generation by manufacturing value-added products from the granite stone waste will boost up the economy of the granite stone industry. The utilization of granite powder in high performance concrete could turn this waste material into a valuable resource with the added benefit of preserving environment. A study conducted by **Dr. T. Felix Kala** focuses on the possibility of using locally available granite powder and admixtures in the production of High Performance Concrete (HPC) with 28 days strength to the maximum of 60 Mpa [7].

Stone has played a significant role in human endeavors since earliest recorded history and its use has evolved since ancient time. Granite industry has grown significantly in the last decades with the privatization trend in the early 1990s as the flourishing construction industry in the World. Accordingly, the amount of mining and processing waste has increased. Granite reserves in India are estimated at 1200 million tonnes. Granite industries in India produce more than 3500 metric tonnes of Granite powder slurry per day as waste product. Granite tiles manufacturing industries are also producing tonnes of granite dust/slurry during the manufacturing process. When dumped on land, these wastes adversely affect the productivity of land due to decreased porosity, water absorption, water percolation etc. They cause serious environmental and dust pollution and require vast area of land for their disposal.

The effect of using granite dust on producing concrete bricks was also studied by **Hamza et.al,** the test results showed that the use of granite dust had a positive effect and the optimum granite content was 10 % [5].

Baboo Rai et.al (2011), investigated the effect of using powder and granules as constituents of fines in concrete by partially reducing quantities of cement as well as other conventional fines. The values of workability, compressive strength and flexural strengths were found. Partial replacement of cement and usual fine aggregates with varying percentage of marble powder (0%, 5%, 10%, 15%, and 20%) and marble granules revealed that increased Waste Marble Powder (WMP) or Waste Marble Granule (WMG) resulted in increase in workability and compressive strength of mortar concrete [8].

Conventionally, Concrete is a mixture of Cement, Sand and Aggregate. Properties of aggregate affect the durability and performance of concrete, so fine aggregate is an essential component of concrete. The most commonly used fine aggregate is natural river or pit sand. Fine and coarse aggregate constitute about 75% of total volume of the concrete. It is therefore, important to obtain right type and good quality aggregate at site, because the aggregate form the main matrix of concrete or mortar [1]. In general, the demand of natural sand is quite high in developing countries to satisfy the rapid infrastructural growth, in this situation developing country like India is facing shortage in good quality natural sand [2]. Because of its limited supply, the cost of Natural River sand has sky rocketed and its consistent supply cannot be guaranteed. Under this circumstances use of M.Sand becomes inevitable. River sand in many parts of the country is not graded properly and has excessive silt and organic impurities and these can be detrimental to durability of steel in concrete whereas M. Sand has no silt or organic impurities.

The progress in the building material research and identification of role of particle shape and gradation of fine aggregates triggered the use of manufactured sand in the production of concrete. The complexity of construction and use of high strength concrete in large number of buildings is the prime mover along with the scarcity of river sand in many cities.

However, many people in India have doubts about quality of concrete or mortars when manufactured or artificial sand are used. Manufactured sand has been regularly used to make quality concrete for decades in India and abroad. Pune - Mumbai expressway was completely built using manufactured sand [3].

Tamil Nadu Government (India) has imposed restrictions on sand removal from the river beds due to unsafe impacts threatening many parts of the state. On the other hand, the granite waste generated by the industry has accumulated over years. Only insignificant quantities have been utilized and the rest has been dumped unscrupulously resulting in environment problem [4].

Katz & Baum (2006) reported that the fine aggregates (smaller than 4.75 mm, No. 4 mesh) play a very important role in controlling the properties of fresh concrete. They help to improve the cohesiveness of fresh concrete, improve its workability and prevent segregation as well as bleeding. **Kumar et.al (2006),** investigated the flexural behaviour of high-performance reinforced concrete beams using sandstone aggregates. **Hudson (1999)** reported that, ‘‘concrete manufactured with a high percentage of minus 75 micron material will yield a more cohesive mix than concrete made with typical natural sand’’. The experiments conducted by **Mishra at PWD Research Institution, Lucknow (1984),** on use of stone dust in cement mortars explains the influence of Shape and Size of fine aggregate on strength of mortars The experiments conducted by **Dr. D.S. Prakash Rao and V. Giridhar Kumar (2004)** on strength characteristics of concrete with stone dust as fine aggregate, draws the following conclusions-The concrete cubes with crusher dust developed about 17% higher strength in compression, 7% more split tensile strength and 20% more flexural strength (Modulus of Rupture) than the Concrete cubes/beams with river sand as fine aggregate. Similarly, Reinforced Concrete Beams with crusher dust sustained about 6% more load under two point loading and developed smaller deflections and smaller strains than the beams with river sand [10].

RESEARCH SIGNIFICANCE

The main objective of the work was to systematically study the effect of Granite Powder as Partial Replacement to Cement in the Design of Ready Mix Concrete of M20 Grade and to arrive at an optimum percentage to be mixed in the concrete with due consideration of its technical suitability. Compressive Strength Property was investigated for 5% to 40% with an increment of 5% of Granite powder as partial replacement to cement. The adopted water to cement ratio was 0.53. Corrections for moisture absorption and moisture content were suitably applied for all the batches of mix. Manufactured Sand was used in place of the Natural River Sand. Research on Granite Powder as partial replacement to Cement and Concrete along with M. Sand in making Ready Mix Concrete is scarce and hence this paper investigates the Compressive Strength behaviour of Ready Mix Concrete (RMC) with Granite Powder and Manufactured Sand (M. Sand).

MATERIALS

*1. Cement***:** Ordinary Portland Cement (OPC) of 53 Grade of UltraTech conforming to IS: 12269-1987 was used. The test conducted on Cement is shown in Table 1.

Table 1: Properties of Cement

Test Conducted	Result	Requirements
Normal Consistency (%)	28.50	26% to 33% (General Requirement)
Specific Gravity	3.15	Should not be less than 3.10
Initial Setting time (minutes)	140	Minimum 30 minutes (IS 4031-Part 5-1988)
Final Setting time (minutes)	715	Maximum 600 minutes (IS 4031-Part 5-1988)
Fineness in 90μ sieve (%)	3.12	Maximum 10% (IS:269-1976)

2. Granite Powder: Locally available Granite Powder was used. It was obtained from Thandya Industrial Area, Nanjangud, Mysore District, Karnataka, India. Granite Powder Source, Properties and Chemical Composition of Granite Powder are shown in Table 2, Table 3 and Table 4.

Table 2: Granite Industries of Mysore District and Chamarajanagar, Karnataka, India

No. of Minor Industries	No. of Major Industries	Location
10	9	Chamarajanagar Town and Badanaguppe, Karnataka
6	8	Thandya Industrial Area, Nanjangud, Mysore District, Karnataka*
5	6	Nanjangud Industrial Area, Mysore District Karnataka
5	3	Mysore Industrial Area including Hebbal, Elawala and Belagola, Karnataka
*Source from where the Granite Powder has been brought and used in this Study.		

Table 3: Properties of Granite Powder

Test Conducted	Result	Requirements as per IS 383-1970 (Reaffirmed 2007)
Specific Gravity	2.65	---
Water Absorption (%)	10	---
Deleterious Material (%) 1. Light weight pieces 2. Material finer than 75µ	 0.18 73.5	 Max. 1% by weight ---
Chloride as Cl. (% by mass)	0.0096	---
Sulphate as SO_3 (% by mass)	0.0051	---
Soundness (% by mass) after 5 cycles 1. Sodium Sulphate 2. Magnesium Sulphate	 4.86 5.48	 Max. 10% Max.15%
Alkali Aggregate Reactivity: (Millimoles/ litre) 1.Reduction in alkalinity of 1.0 N NaOH 2.Silica dissolved	 40.00 22.44	As per IS: 2389-Part VII-1963 (Reaffirmed-2007) The samples fall under innocuous aggregate i.e., the samples do not indicated potential deleterious degree of alkali reactivity.

Table 4: Chemical Composition of Granite Powder

Chemical Composition	Constituents in Percentage
SiO2 (Silica)	58.36
Al2O3 (Alumina)	12.63
Fe2O3 (Iron Oxide)	21.54
TiO2 (Titanium Dioxide)	1.40
CaO (Lime)	1.34
MgO (Magnesium Oxide)	1.29
Na_2O (Sodium Oxide)	1.75
K_2O (Potassium Oxide)	0.52
Loss On Ignition (LOI) = 1.19 %	

Table 5: Properties of M.Sand

Test	Result	Requirements as per IS 383:1970 (Reaffirmed 2007)
Specific Gravity	02.64	---
Water Absorption (%)	04.50	---
Silt Content by Weight method (%)	10.07	It should not be more than 15%
Silt Content by Volume method (%)	04.74	It should not be more than 15%

3. Fine Aggregate: Locally available manufactured sand free from silt, organic matter and passing through 4.75mm Sieve conforming to zone II of IS: 383-1970 was used. The tests conducted on Fine Aggregate are shown in Table 5 and Table 6.

Table 6: Sieve Analysis of M.Sand

Indian Standard Sieve Designation	4.75mm	2.36mm	1.18mm	600µm	300µm	150µm
Percentage Passing	99.80	97.10	80.30	59.30	35.90	18.10

4. Coarse Aggregate: 55 % of 20 mm and 45% of 12.5 mm of the total quantity of the Coarse aggregate was used as per the requirements of Ready Mix Concrete Plant. The tests conducted on Coarse Aggregate are shown in Table 7 and Table 8.

Table 7: Sieve Analysis of Coarse Aggregate - 20mm

Indian Standard Sieve Designation	20mm	10mm	4.75mm
Percentage Passing	88.07	3.73	0.57

Table 8: Sieve Analysis of Coarse Aggregate - 12.5mm

Indian Standard Sieve Designation	12.5mm	10mm	4.75mm
Percentage Passing	87.50	24.60	4.80

5. Admixture: Superplasticizer, **Rheobuild 920 (UT)** was used. It is a High Range Water Reducing (HRWR) admixture.

6. Water: Potable water was used. The test conducted on mixing water is shown in Table 9.

Table 9: Properties of Mixing Water

Parameters	Results	IS 456:2000 Stipulations
Quantity of 0.02 N NaOH required to neutralize 100ml of water sample using Phenolphthalein as an Indicator	0.6	<5ml
Quantity of 0.02 N H_2SO_4 required to neutralize 100ml of water sample using mixed indicator	16ml	<25ml
Chlorides as Cl	214mg/lit	500mg/L max for R.C.C & 2000 mg/L max for P.C.C
Sulphates as SO_4	12mg/lit	400 mg/L max
Inorganic solids	624mg/lit	3000 mg/L max
Suspended matter	BDL*	2000 mg/L max
Organic solids	112mg/lit	200 mg/L max
PH value	7.87	>6
BDL*: Below Detection Limit		

MIX DESIGN for TRIAL MIX 1 (REFERENCE MIX) as per Indian Standard Concrete Mix Proportioning-Guidelines (IS 10262: 2009)

1. Stipulations for Proportioning

1. Grade designation : M 20
2. Type of cement : OPC 53 Grade
3. Maximum nominal size of aggregate : 20 mm
4. Minimum cement content : 320 kg/m^3
5. Maximum w/c ratio : 0.55
6. Workability : 100mm (slump)
7. Exposure condition : Mild
8. Method of concrete placing : Pumping
9. Degree of supervision : Good
10. Type of aggregate : Crushed angular aggregate
11. Maximum cement content : 450 kg/m^3
12. Chemical admixture type : Superplasticizer

2. Test Data for Materials

1. Cement used : OPC 53 grade (UltraTech)
2. Specific Gravity of cement : 3.15
3. Chemical Admixture : Superplasticizer conforming IS 9103
4. Specific Gravity of Coarse Aggregate : 2.65
5. Specific Gravity of Fine Aggregate : 2.65
6. Water Absorption (Coarse aggregate) : Varies with the condition
7. Water Absorption (Fine aggregate) : Varies with the condition
8. Free Moisture (Coarse and fine Aggregate) : Nil
9. Sieve Analysis : Confirming Table 2 of IS 383

3. Target Strength for Mix proportioning

$f'_{ck} = f_{ck} + 1.65\,s$

Where

f'_{ck} = Target Mean Compressive Strength at 28 days in N/mm^2

f_{ck} = Characteristic Compressive Strength at 28 days in N/mm^2

s = Standard Deviation, s= 4 N/mm^2 (Table 1 of IS 10262: 2009)

Therefore,

$f'_{ck} = 20 + 1.65(4)$

Target Mean Strength = 26.6 N/mm^2

4. Selection of Water to Cement ratio

Maximum Water to Cement ratio = 0.55 (Table 5 of IS 456:2000)

Based on experience, adopt water cement ratio as 0.53.

0.53 < 0.55. Hence Ok.

5. Selection of water content

Maximum Water Content for 20mm Aggregate = 186 liter (for 25 to 50mm slump)
Estimated Water Content for 100 mm Slump = 1.06 x 186 = 197 liter (6% more for 100 mm Slump)
As superplasticizer is used, the water content is reduced up to 20% and above. Based on trials with Superplasticizer water content reduction of 29% has been achieved.
Hence the arrived water content = 197 X 0.71 = 140 litre.

6. Calculation of cement content

Water -Cement ratio = 0.53
Cement content = 140/0.53 = 264 Kg/m^3
Minimum Cement content = 300 Kg/m^3 From **(**Table 5 of IS 456 2000)
270 Kg/m^3 < 300 Kg/m^3. Hence adopt 300 Kg/m^3
Therefore, Water to Cement ratio = 0.53 X 300 =159 liters. Adopt 160 liters

7. Proportion of volume of coarse aggregate and fine aggregate content

Volume of Coarse Aggregate corresponding to 20 mm size aggregate and fine aggregate (Zone II) for a water to cement ratio of 0.50 = 0.62. Therefore, for a water cement ratio of 0.53, it is reduced to 0.614. (At the rate of +/- 0.01 for every +/- 0.05 change in water-cement ratio)
For pumpable concrete these values may be reduced by up to 10%.
Therefore, Volume of Coarse Aggregate = 0.614 X 0.945 = 0.58 (Say 5.5% reduction)
Volume of Fine Aggregate content = 1 – 0.58= 0.42

8. Mix calculations

The Mix Calculations per Unit Volume of Concrete shall be as follows:

1. Volume of Concrete = 1 m^3

2. Volume of Cement
   = Mass of Cement / (Specific Gravity of Cement x 1000) = 300/ (3.15 x 1000)
   = 0.09524 m^3
3. Volume of Water
   = Mass of Water / (Specific Gravity of Water x 1000) = 160/ (1 x 1000)
   = 0.160 m^3
4. Volume of Admixture (1% of Weight of Cement)
   = Mass of Admixture / (Specific Gravity of Admixture x 1000) = 3 / (1.18 x 1000)
   = 0.00254 m^3
5. Volume of all in aggregate (V_a)
   = 1 – (Volume of Cement +Volume of Water + Volume of Admixture)
   = 1- (0.09524 + 0.160 + 0.00254)
   = 0.7422 m^3
6. Mass of Coarse Aggregate
   = V_a x (Volume of Coarse Aggregate x Specific Gravity of Coarse Aggregate x 1000)
   = 0.7422 x 0.58 x 2.65 x 1000
   = 1140.80 kg
   In RMC Plant, based on experience and tests for Pumpable Concrete, the Percentage of Coarse Aggregate can be adopted according to their Size.
   55% of 20 mm = 1140.80 x 0.55 = 627.44 kg
   45% of 12.5 mm = 1140.80 x 0.45 = 513.36 kg
7. Mass of Fine Aggregate
   = V_a X (Volume of Fine Aggregate X Specific Gravity of Fine Aggregate x 1000)
   = 0.7422 x 0.42 x 2.65 x1000
   = 826.09 kg

9. Mix proportions for Reference Mix (Trial Mix no.1)

Cement	= 300.00 kg m^3
Water	= 160.00 kg/m^3
Coarse aggregate 20mm	= 627.44 kg/m^3
Coarse aggregate 12 mm	= 513.36 kg/m^3
Fine aggregate	= 826.09 kg/ m^3
Chemical Admixture	= 3.00 Kg/m^3
Water cement ratio	= 0.53

Proportion by Weight of Reference Mix is 1: 2.75: 3.8 (Cement: Fine Aggregate: Coarse Aggregate)

EXPERIMENTAL INVESTIGATION

The Workability and Compressive strength were studied on concrete with partial replacement of Cement by Granite Powder. The Mix proportions were carried out with 5%, 10%, 15%, 20%, 25%, 30%, 35% and 40% of replacement of cement with Granite Powder. Manufactured Sand was used as Fine aggregate. The concrete ingredients were first mixed in dry state and then the water was added. The various ingredients are thoroughly mixed to get a homogeneous Concrete. Workability of fresh concrete was determined by conducting Slump tests and Compacting factor tests. Compressive strengths were measured on 150mm cubes at 7 days, 14 days and 28 days. Then the percentage variation in Compressive strength was determined. For each trial mix, 9 cubes were casted. Mix Design, Workability of M20 Ready Mix Concrete and Test Results are shown in the Table 10, Table 11 and Table 12.

Table 10: Concrete Mix design for M20 Ready Mix Concrete

Material	Quantity	Cement	Granite Powder	CA 20mm	CA 12mm	Manufactured Sand	Admixture	Water
Trial Mix No.1*	BQ	300	0	627.440	513.360	826.090	3	160.000
	CQ	300	0	624.303	510.793	797.177	3	194.620
Trial Mix No.2	BQ	285	15	627.440	513.360	826.090	3	160.000
	CQ	285	15	624.303	510.793	797.177	3	194.617
Trial Mix No.3	BQ	270	30	627.440	513.360	826.090	3	160.000
	CQ	270	30	624.303	510.793	797.177	3	194.617
Trial Mix No.4	BQ	255	45	627.440	513.360	826.090	3	160.000
	CQ	255	45	624.303	510.793	788.916	3	202.878
Trial Mix No.5	BQ	240	60	627.440	513.360	826.090	3	160.000
	CQ	240	60	624.303	510.793	788.916	3	202.878
Trial Mix No.6	BQ	225	75	627.440	513.360	826.090	3	160.000
	CQ	225	75	624.303	510.793	798.829	3	192.965
Trial Mix No.7	BQ	210	90	627.440	513.360	826.090	3	160.000
	CQ	210	90	624.303	510.793	792.220	3	199.574
Trial Mix No.8	BQ	195	105	627.440	513.360	826.090	3	160.000
	CQ	195	105	624.303	510.793	793.872	3	197.922
Trial Mix No.9	BQ	180	120	627.440	513.360	826.090	3	160.000
	CQ	180	120	624.303	510.793	793.872	3	197.922
Trial Mix No.1*: Reference Mix, CA: Coarse Aggregate, BQ: Batch Quantity in Saturated Surface Dry Condition, CQ: Corrected Batch Quantity								

Table 11: Workability of M20 Ready Mix Concrete

Material	Granite Powder used as Partial Replacement to Cement (%)	Slump (mm)			Compaction Factor
		Initial	30'	60'	
Trial Mix No.1	00	150	120	85	0.92
Trial Mix No.2	05	125	100	75	0.92
Trial Mix No.3	10	120	60	50	0.91
Trial Mix No.4	15	145	90	50	0.90
Trial Mix No.5	20	180	165	115	0.90
Trial Mix No.6	25	165	145	120	0.89
Trial Mix No.7	30	155	125	85	0.89
Trial Mix No.8	35	145	120	95	0.90
Trial Mix No.9	40	140	105	85	0.93

Table 12: Test Results of M20 Ready Mix Concrete

Material	Granite Powder used as Partial Replacement to Cement (%)	Compressive Strength at 7 days (Mpa)	Percentage Variation in Compressive Strength at 7 days (%)	Compressive Strength at 14 days (Mpa)	Percentage Variation in Compressive Strength at 14 days (%)	Compressive Strength at 28 days (Mpa)	Percentage Variation in Compressive Strength at 28 days (%)
Trial Mix No.1	00	36.56	---	42.30	---	47.29	---
Trial Mix No.2	05	36.62	00.16	40.16	-5.06	41.08	-13.13
Trial Mix No.3	10	32.34	-11.54	34.30	-18.91	40.82	-13.68
Trial Mix No.4	15	26.40	-27.79	29.31	-30.71	35.15	-25.67
Trial Mix No.5	20	21.83	-40.29	24.60	-41.84	30.14	-36.27
Trial Mix No.6	25	18.69	-48.88	20.61	-51.28	24.46	-48.28
Trial Mix No.7	30	17.84	-51.20	19.60	-53.66	23.15	-51.05
Trial Mix No.8	35	17.92	-50.98	19.22	-54.56	21.82	-53.86
Trial Mix No.9	40	18.61	-49.10	19.44	-54.04	21.11	-55.36
Negative sign indicates the Percentage decrease in the Compressive Strength with reference to the Reference Mix (Trial Mix 1)							

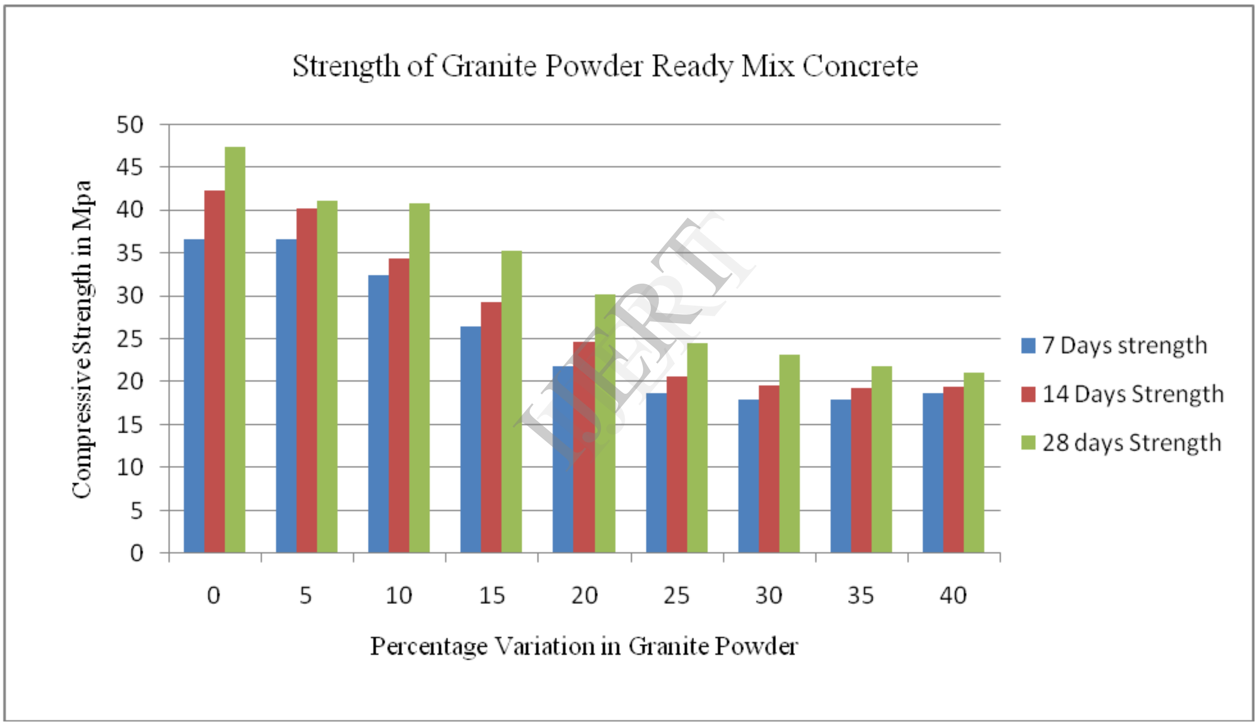

Figure 1: Strength of Granite Powder Ready Mix Concrete

RESULTS AND DISCUSSION

Fresh concrete

Workability: The Concrete Mixes of all batches were cohesive and there was no bleeding and segregation. Initial slumps of 145mm for 35% replacement and 140mm for 40% replacement were observed. Slumps of 95mm for 35% replacement and 85mm for 40% replacement at the end of 60 minutes were observed, which satisfies the requirement of Ready Mix Concrete. The observed Compaction factor at 35% and 40% replacements were 0.9 and 0.93 which satisfies the workability requirements of Ready Mix Concrete. 180mm and 115 mm were the observed slumps at the beginning and at the end of 60 minutes respectively for 20% replacement. The Compaction factor was 0.9 for 20% replacement which satisfies the requirements of Ready Mix Pumpable Concrete.

Hardened Concrete

Compressive strength: Concrete Mixes revealed decrease in Compressive strength compared to the Reference Mix at various replacements. However, Compressive strength at 28 days with 20% replacement was 30.14 Mpa. Figure 1 shows the Compressive Strengths at 7days, 14days and 28 days.

CONCLUSION

1. Compressive strengths of 30.14 Mpa and 24.46 Mpa were obtained for 20% and 25% replacements from which the optimum percentage of replacement can be established for the Target Mean Strength of 26.6 Mpa which was calculated in the Mix Design. This works out to be 23.11 % by interpolation. 20% will be the ideal replacement.
2. The cost of construction can be minimized by using Granite Powder which is available at free of cost.
3. Environmental Pollution can be minimized by reducing the production of cement and also the health hazards can be controlled by using the Granite powder as the partial replacement to Cement.
4. Manufactured sand gives better surface finishes and can be conveniently used in making the Ready Mix Concrete. Considering, the acute shortage of river sand, huge short-comings on quality of river sand, high cost, greater impact on road damages and environmental effects, the M. Sand proves to be one of the best alternatives to the Natural River Sand.
5. The Construction Industry shall start using Manufactured Sand to the full extent as alternative to the Natural River Sand.

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REFERENCES

1. Hudson, B. P., “Manufactured Sand for concrete,” The Indian concrete Journal, May 1997, pp. 237-240.
2. Safiuddin, M.; Raman, S. N., and Zain, M. F. N., “Utilization of Quarry Waste Fine Aggregate in Concrete Mixtures,” Journal of Applied Sciences Research, V.3, 2007, pp. 202-208.
3. G.Sreenivasa, General Manager (Business Development), UltraTech Cement Limited Bangalore, “Use of Manufactured Sand in Concrete and Construction-An Alternate to River Sand”. NBM Media, India’s No1 Construction Portal
4. T. Felix Kala and P. Partheeban, “Granite powder concrete”. Indian Journal of Science and Technology, Vol. 3 No. 3 (Mar 2010) pp 311-317
5. Hamza, K.K Aizboon, “Effect of using granite slurry in concrete”, Construction and building materials, 10-2013, pp 1014-1020
6. Rahul et.al, “Project on Partial Replacement of Cement with Marble Powder”, Civil Engineering Portal
7. Dr.T. Felix Kala, “Effect of Granite Powder on Strength Properties of Concrete” International Journal of Engineering and Science, Vol.2, Issue 12 (May 2013), Pp 36-50
8. Dr.G.Prince Arulraj, “GRANITE POWDER CONCRETE”, IRACST – Engineering Science and Technology: An International Journal (ESTIJ), Vol.3, No.1, February 2013 pp 193-198
9. P A Shirule et.al, “Partial replacement of cement with marble dust powder”, International journal of Advanced Engineering Research and Studies, Vol. I/ Issue III/April-June, 2012/175-177
10. V. Bhikshma. et.al, “Flexural behavior of high strength stone dust concrete, Challenges, Opportunities and Solutions in Structural Engineering and Construction.” – Ghafoori (ed.) © 2010 Taylor & Francis Group, London, ISBN 978-0-415-56809-8, pp 491-494.